Title:	Bending Light with Scratch
Grade(s):	5
Subject(s):	Science
Author:	ICAC Team
Overview:	The teacher will lead a discussion about concave and convex lenses and review basic concepts of the refraction of light. Students will use Scratch on the computer to create an animation showing light rays passing through concave and convex lenses.
Content Standards:	Sci (5) 5. Contrast ways in which light rays are bent by concave and convex lenses. TC (3-5) 1. Use input and output devices of technology systems. TC (3-5) 2. Use various technology applications, including word processing and multimedia software. TC (3-5) 12. Create a product using digital tools.
Local/National Standards:	
Primary Learning Objectives:	The student will: Develop an understanding of the interaction between light rays and concave and convex lenses. Develop an understanding of Scratch on the computer by using the program to create an animation showing the bending of light rays by convex and concave lenses.
Additional Learning Objectives:	
Approximate Duration of Lesson:	60 min.
Materials and Equipment:	
Technology Resources Needed:	Computer with **Scratch** program.
Background/ Preparation:	**Scratch** can be downloaded onto the computers beforehand or the students can download the program during the lesson. **Scratch** is a free program created by MIT. To downlaod **Scratch** on to the Computer: • Go to: scratch.mit.edu • Click on the orange button to download **Scratch.**
Procedures/ Activities:	Step 1 Ask students to list the properties of a lens. *(It must be made of a transparent material, either a solid or a clear liquid, and have a curved surface in order to bend light.)* On the board, place a drawing of a convex lens and a concave lens showing light paths through the lenses.

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project "Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."
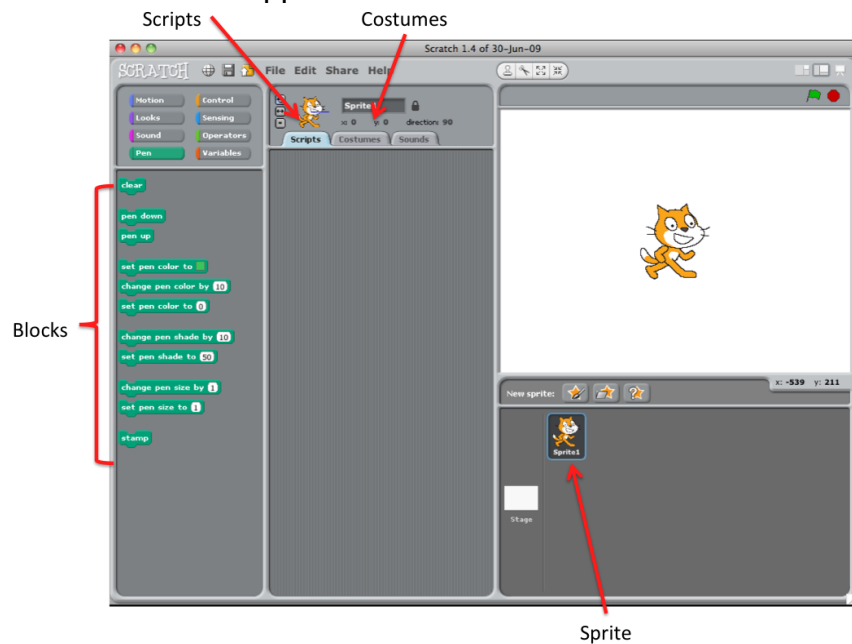
1

Discuss the reasons that light is bent by a lens. *(Light waves slow down when they travel through a medium denser than air, such as glass or plastic.*
Do the Bending Light Wave demonstration with 3 student volunteers. See example of Lens Demo *on YouTube.)*

Ask students to tell you the difference between convex and concave lenses. (**Convex** *lenses are thicker in the center than at the edges.* **Concave** *lenses are thicker at the edges than at the middle.* **Concave** *lenses bend light waves to spread light apart and* **convex** *lenses bend light waves to make them come together.)*
Ask students how they could use a computer to show the way each type of lens bends light.

Step 2 Students can work individually or in small groups. Guide the students through the process of creating a simulation for the convex lens. Tell them that when you have finished modeling the convex lens, it will be their challenge to create a simulation for a concave lens.

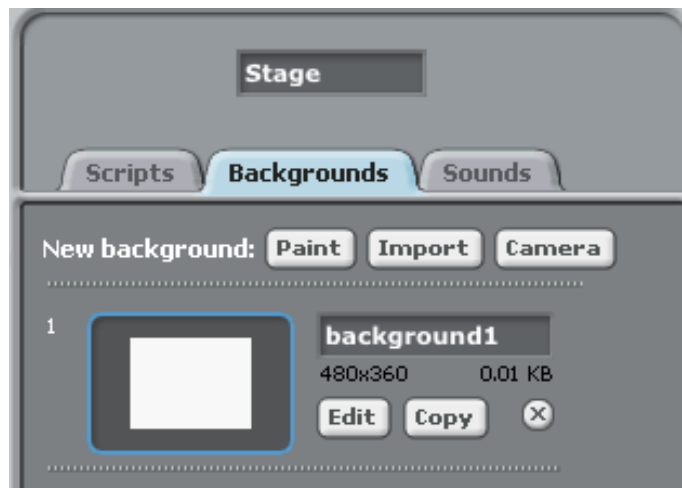**Step 3** Open the **Scratch** program.

This window will appear:

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project

"Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

2

Step 4   The students will first need to draw the convex lens. Click on the **Stage** beneath the white **canvas**.
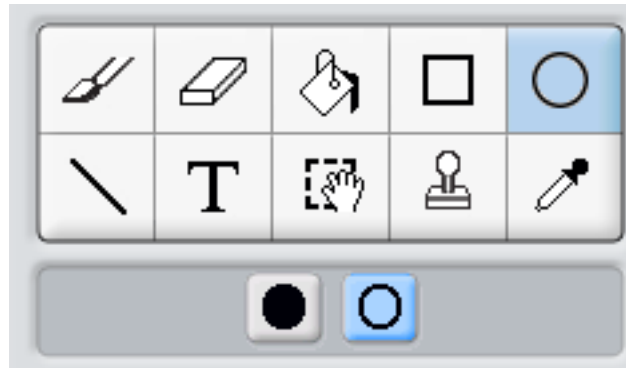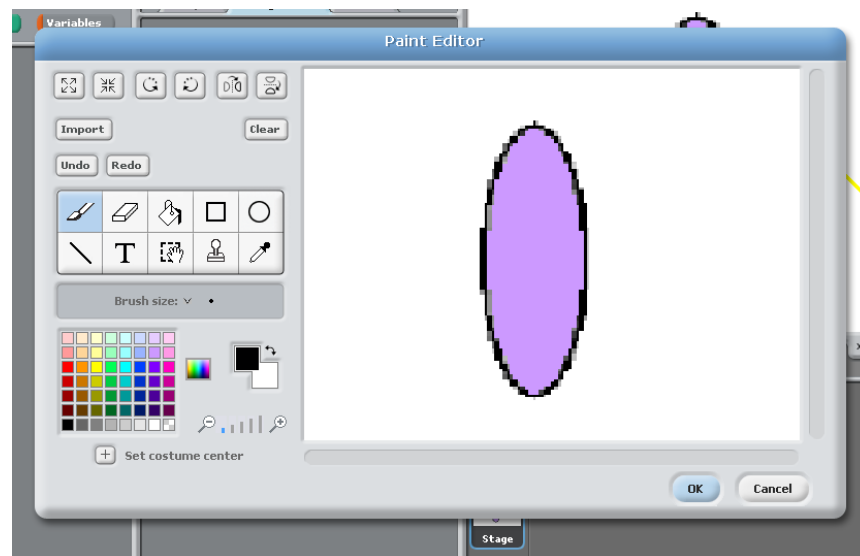

Convex Lens
To create the Convex Lens Background, click on the **Backgrounds** tab and then the **Edit** button.

In the **Paint Editor** box, select the **Ellipse tool**. Also, select **Outline** (rather than fill).

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project
"Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."
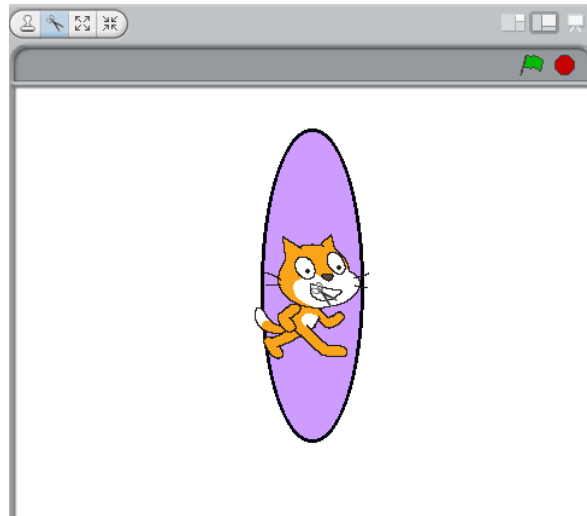
3

Click and drag the mouse cursor to create a large convex lens in the middle of the Paint editor. Select a color from **Palette** and use the **Fill tool** to color in the convex lens.
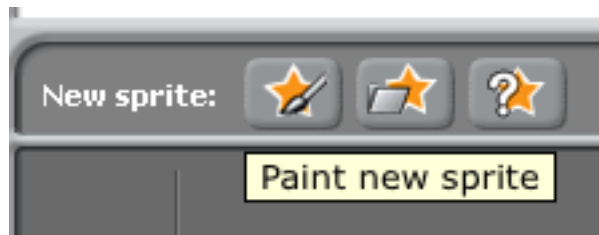

Press **OK**. The created lens will now be displayed on the canvas.

Step 5   Next the students will create three arrows to represent three light waves approaching the lens, one at the top, one in the middle, and one at the bottom. When the arrows pass through the lens, they will come together and converge at the focal point.
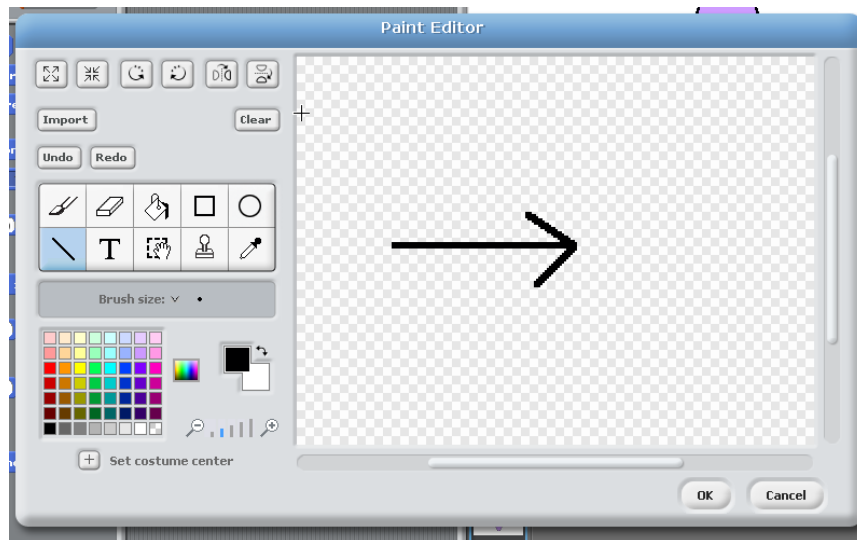
To create the **Arrow** sprite, first delete the **Cat** sprite. Click on the **scissors** above the white canvas and then click on the cat to delete it.

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project "Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

4

To draw the top arrow, click on the leftmost icon underneath the canvas to paint a new sprite.

Use the **Line too**l in the Paint editor to draw an arrow.

Click **OK** to add this sprite to the project.

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project "Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

5

Now duplicate the arrow sprite twice, by right clicking on the arrow underneath the stage and selecting **duplicate** from the menu. Duplicate the sprite twice to have a total of three sprites.
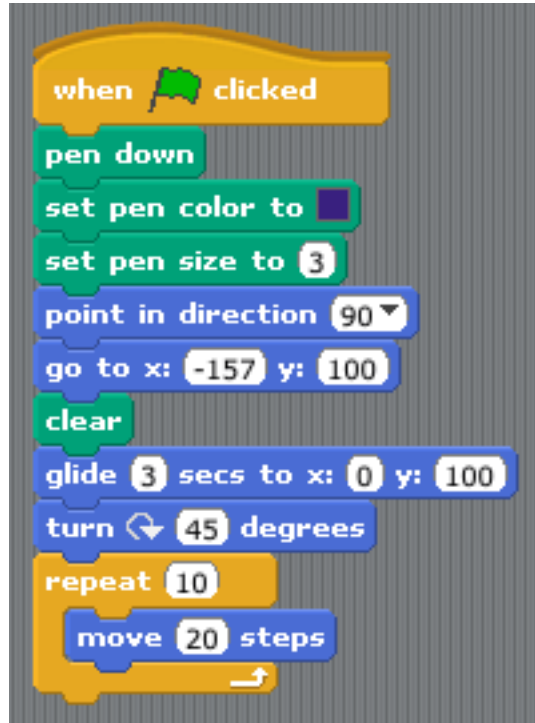

Step 6   Rename the first arrow, **Sprite1** as "**Top.**" This arrow will represent the light waves approaching the top of the convex lens. To rename Sprite1, click on the text "**Sprite1**" at the top of the screen highlighting the text. Delete the text and type "**Top**" to rename it.
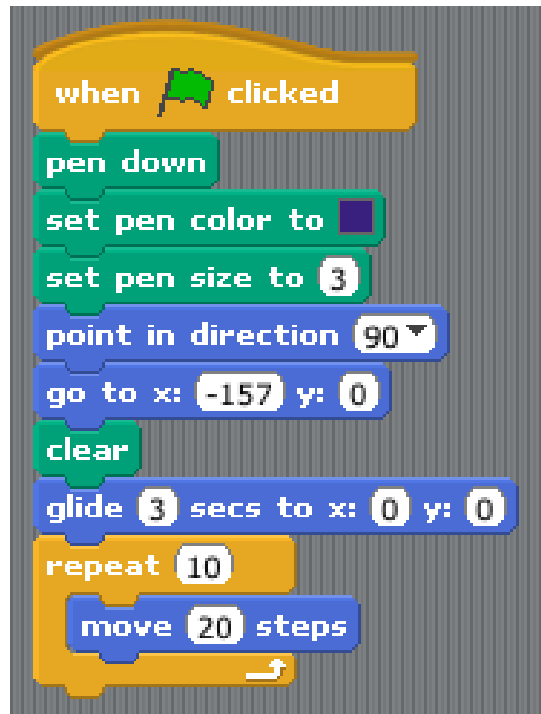

Repeat this Step and rename **Sprite2** and **Sprite3** as "**Center**" and "**Bottom**." These arrows will represent the light waves approaching the center and near the bottom of the lens.

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project "Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

6

Step 7 For the **top arrow**, guide the students through the process of creating the following code:

For the **center arrow**, have the students create the following code:

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project

"Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

7

```
when [flag] clicked
pen down
set pen color to [blue]
set pen size to 3
point in direction 90
go to x: -157 y: 0
clear
glide 3 secs to x: 0 y: 0
repeat 10
    move 20 steps
```
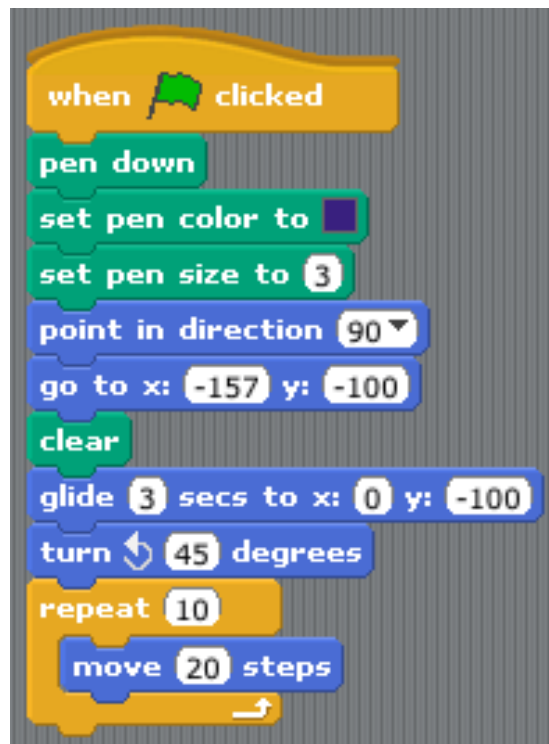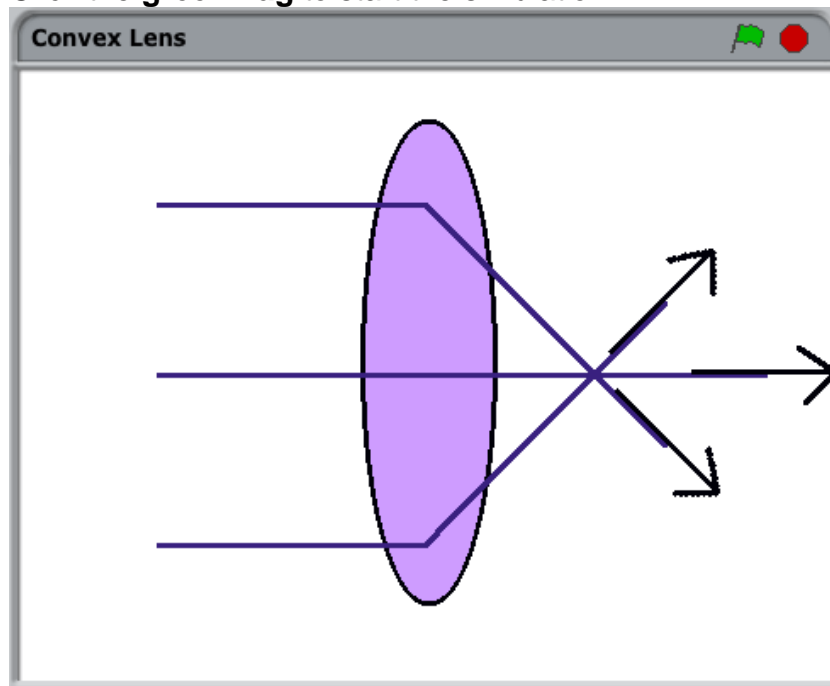
For the **bottom arrow**, have the students create the following code:

```
when [flag] clicked
pen down
set pen color to [blue]
set pen size to 3
point in direction 90
go to x: -157 y: -100
clear
glide 3 secs to x: 0 y: -100
turn 45 degrees
repeat 10
    move 20 steps
```
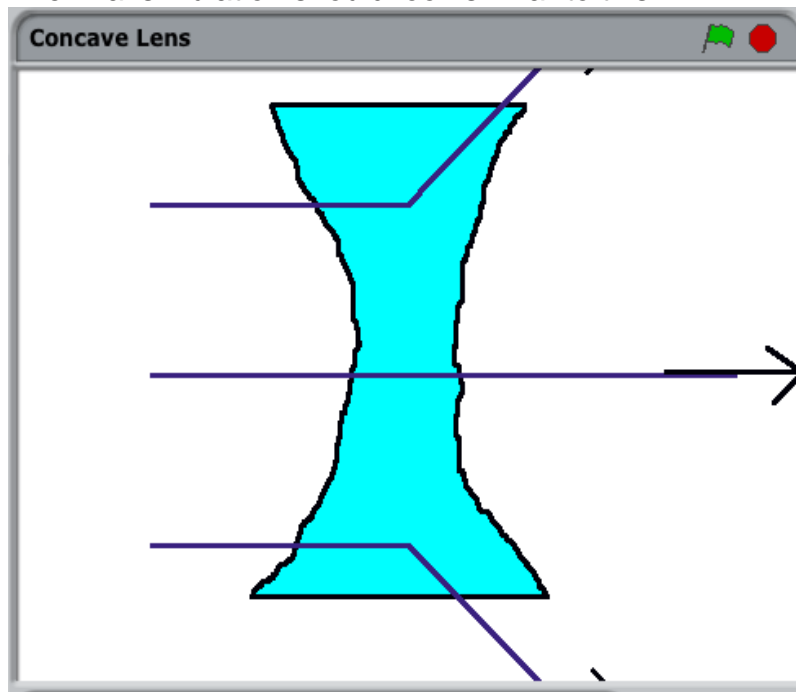
Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project
"Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

8

Step 8   Click the **green flag** to start the simulation.
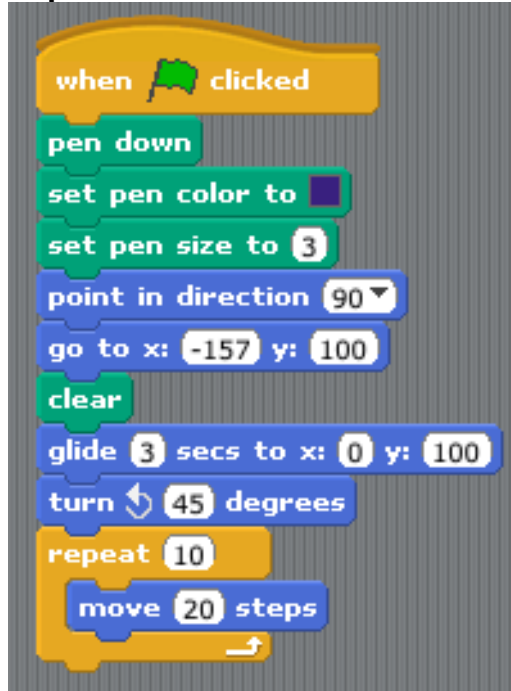
Convex Lens

Step 9   After the students have finished and **saved** their **convex lens** simulation, ask the students to create a new project for a **concave lens** simulation.

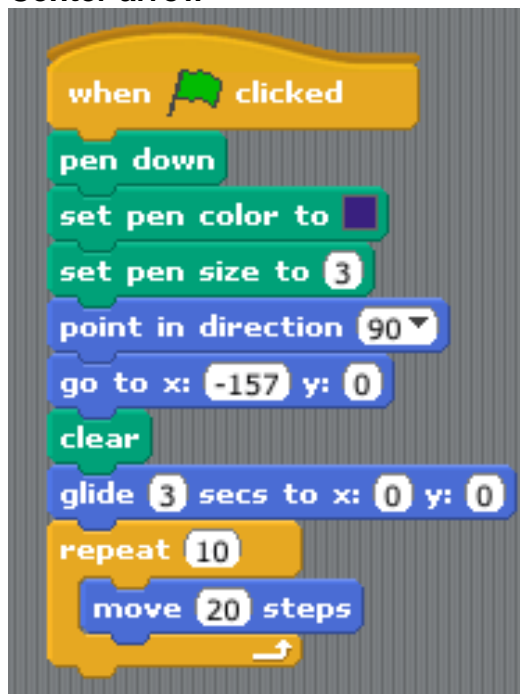The final simulation should look similar to this:

Concave Lens

Sample code for the **concave** arrows include:

Top arrow

```
when [flag] clicked
pen down
set pen color to [purple]
set pen size to 3
point in direction 90
go to x: -157 y: 100
clear
glide 3 secs to x: 0 y: 100
turn ↺ 45 degrees
repeat 10
    move 20 steps
```
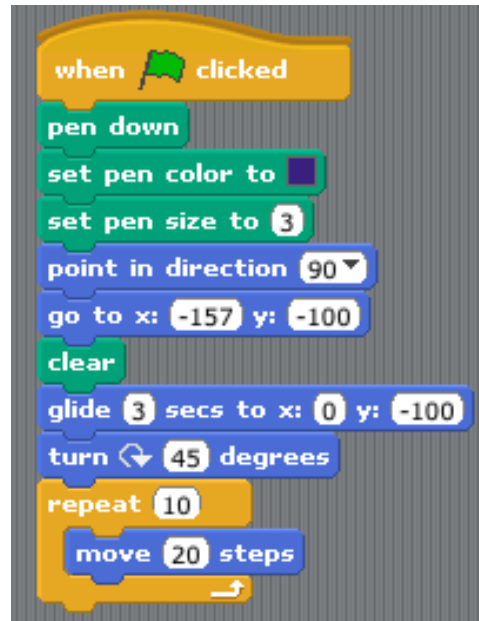
Center arrow

```
when [flag] clicked
pen down
set pen color to [purple]
set pen size to 3
point in direction 90
go to x: -157 y: 0
clear
glide 3 secs to x: 0 y: 0
repeat 10
    move 20 steps
```

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project
"Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

10

Bottom arrow

Attachments:	**Title:** Scratch Reference Guide 1.4 – Scratch Wiki
	URL: http://info.scratch.mit.edu/Support/Reference_Guide_1.4
Assessment	
Strategies:	See attached rubric.
Extension:	The diagram created in this lesson shows the overall effect of the lenses on light waves passing through them, but it is not completely accurate. A light wave will "bend" whenever it moves between substances of different densities, so the wave bends when it moves from air into the glass lens, then bends again when it moves from the other side of the lens back into the air. Have students create another Scratch program to illustrate this light path.
Remediation:	Have students who are successful Scratch programmers work with students who need help in completing their programs.

Lesson Plan format is adapted from the Alabama Learning Exchange (ALEX). Lessons developed by staff of the UAB NSF project
"Integrating Computing Across the Curriculum: Incorporating Technology into STEM Education Using XO Laptops."

11

Assessment Rubric for Scratch Lens Lesson

Score:	1. Needs Work	2. OK	3. Good Job	4. Great!
Participation	Little or no participation in the activity.	Some participation, but didn't work well with the group.	Participated for most of the project and contributed to the group product.	Worked well with all group members; made significant contribution to group product.
Program	The computer program did not accomplish its goal.	The program accomplished its goal, but the result was not smooth or attractive.	The computer program accomplished its goal and produced an attractive result.	The program accomplished its goal, producing an attractive result and students added to the scripts.